NA Review of the NIOSH Construction Research Program

Sub-goal 3.2

Reduce Disorders Associated with Excessive Exposures to Vibration

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Issue (1/2): Vibration Exposures in Construction Sector

- More than 540,000 construction workers are exposed to whole body vibration. The excessive exposure [A(8) > 1.15 m/s^2] can be found at many construction sites.

- The highest percentage of excessive hand-transmitted vibration exposure occurs in the construction sector:

  > 250,000 at A(8) >5.0 m/s^2

(The exposed populations are estimated based on: BLS 2003, 2004; Kittusamy et al., 2004; Palmer et al., 2007)

Issue (2/2): Health Effects of Excessive Vibration Exposures

- Excessive whole body vibration exposure is associated with back pain and several other MSDs (NIOSH, 1998).

- Excessive hand-transmitted vibration exposure could cause hand-arm vibration syndrome (HAVS). It is also a contributing factor of carpal tunnel syndrome (CTS) (NIOSH, 1998).

External Factors (1/2)

- Low awareness of vibration disorders – *acceptance of vibration exposure as part of the work process.*
- Economic cost of technology – Some good tools and anti-vibration devices are available but they could be expensive.
- Large number of small businesses – *limited safety resources*
- Challenges in field and lab research – it takes a long time to develop chronic disorders; there are many influencing and confounding factors; it is extremely difficult to conduct biological studies using human subjects.
- Lack of any OSHA regulation for vibration; no specific classification for recording vibration-induced injuries or disorders.

External Factors (2/2)

- *Several ANSI and ISO standards have been developed.*
- EU countries are imposing Directives/Laws to control excessive vibration exposures.

  - Exposure Directive 2002/44/EC: implemented in 2005 in several countries

  - Machinery Directive 2006/42/EC: to be implemented in 2009

  - 24-26% of EU workers are exposed to vibration.

  - In several EU countries, the 4th (e.g. UK) or 5th (e.g., Italy) largest claim is vibration-induced disorders.

An Brief History of NIOSH's Major Research Activities on Vibration Exposures

- 1973 – 1984: Studied both whole-body and hand-transmitted vibration exposures
- 1989 – Published a Guideline on hand-transmitted vibration exposure.
- 1997 – Published vibration study reviews in Musculoskeletal Disorders and Workplace Factors.
- 2000 – Resumed vibration exposure research

NIOSH's Major Research Activities Related to Vibration Exposures in Construction Since 2000

- The research team in Spokane Research Laboratory, NIOSH:

  Focused on whole-body vibration exposure.

  Example of publication: Kittusamy and Bryan Buchholz, 2004; Viswanathan et al., 2006.

- The research team in ECTB/HELD/NIOSH, Morgantown, WV:

  Focused on hand-transmitted vibration exposure.

Approach 1: Reduce Vibration at Its Source

Vibration Exposure Dose = F{ vibration magnitude, …}

Our study aim: Develop standardized tool test methods for tool evaluation and selection.

Impact wrench test

Chipping hammer test

Approach 2: Reduce Vibration Transmitted to Human Body

Dose = F{ vibration magnitude, isolation effectiveness, …}

Our study aim: Develop standardized test methods for the evaluation and selection of anti-vibration devices.

Anti-vibration glove test

Anti-vibration wrap on a bucking bar

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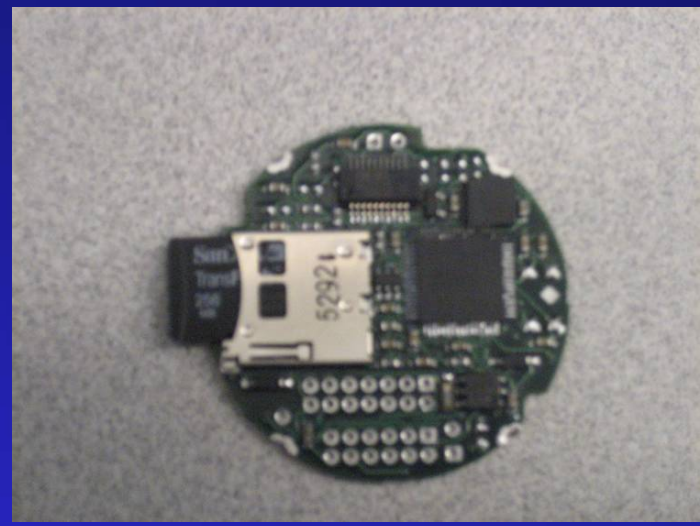
Approach 3: Monitor and Control Vibration Exposure Duration

Dose = F{ vibration magnitude, isolation effectiveness, exposure duration, …}

Our study aim: Develop an effective and practical method to monitor and control the exposure duration

Instrumented watch or dose meter



Wireless dose meter under development

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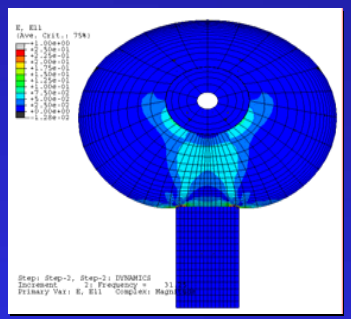
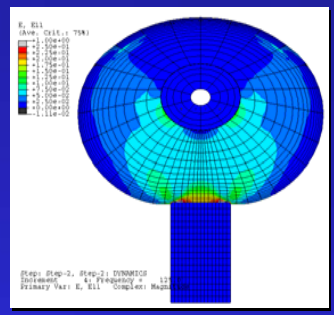
Approach 4: Develop New Methods for Quantifying Vibration Exposure Based on Location-Specific Biodynamic Responses

(We are taking a world leading position in this research direction)

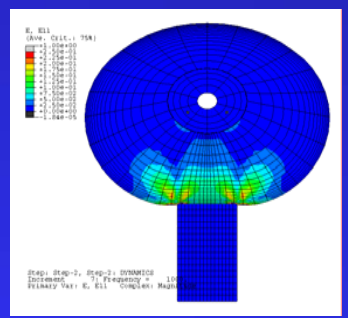
Dose = F{ vibration magnitude, isolation effectiveness, exposure duration, frequency weighting, …}



31.5 Hz

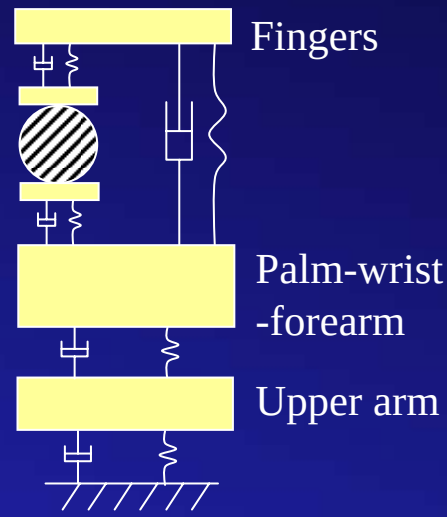


125 Hz



1000 Hz

Finite element modeling of a fingertip



A 5-DOF Model

A novel mechanical-equivalent model of the hand-arm system

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Approach 5: Develop An Effective Method to Take into Account the Effects of Hand Forces and Postures in the Dose Quantification

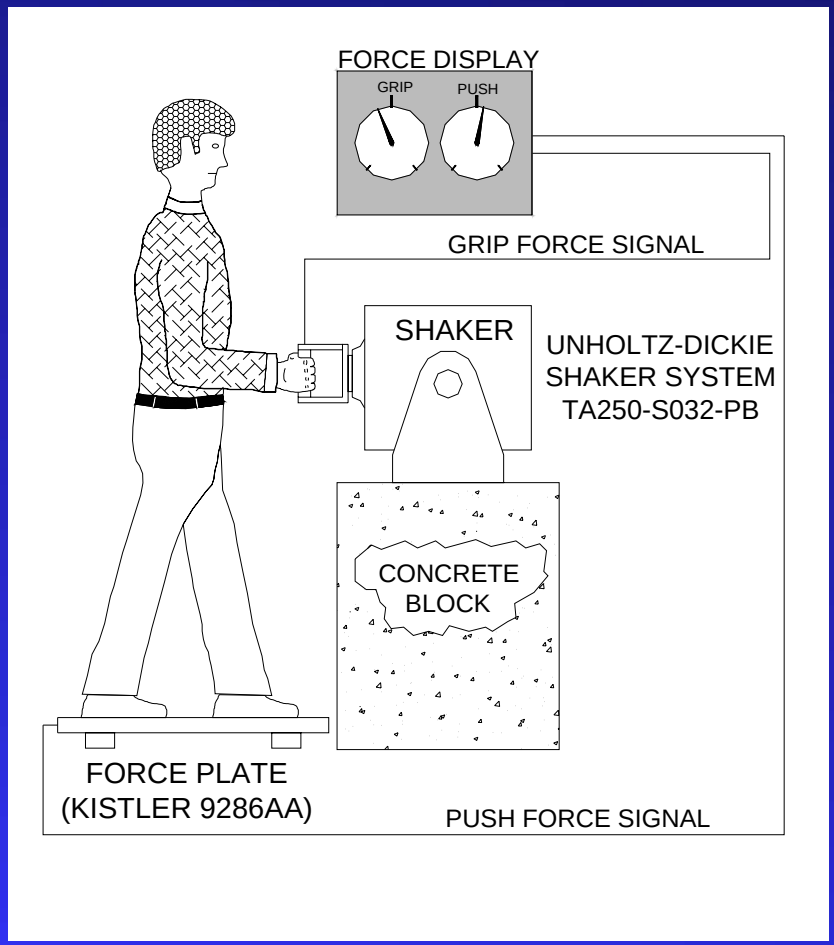
Dose = F{ vibration magnitude, isolation effectiveness, exposure duration, frequency weighting, hand forces and postures, …}

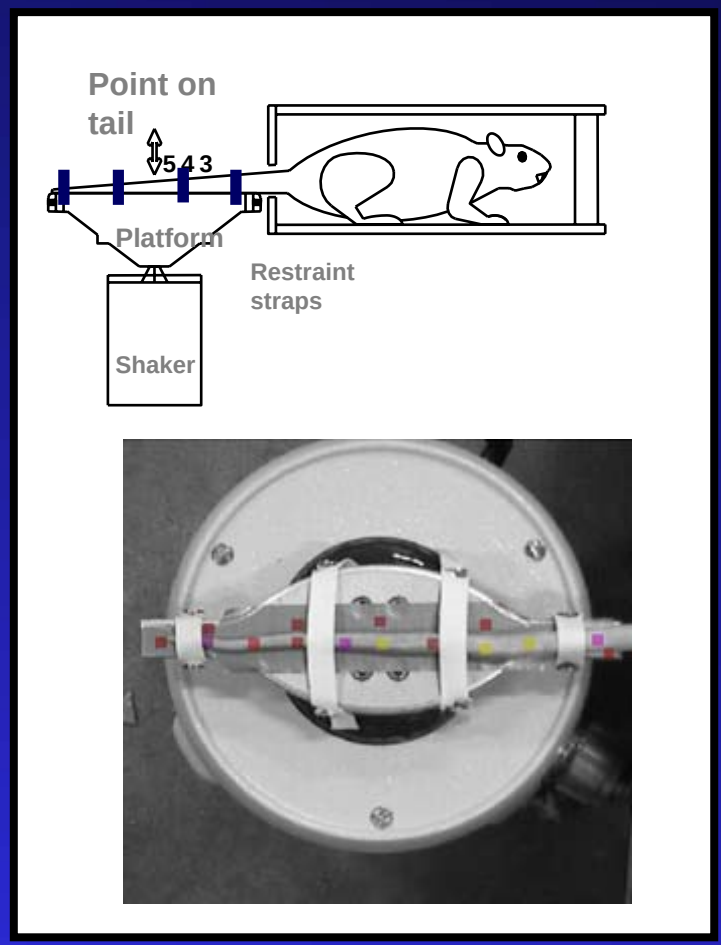
Measurements of hand-handle contact pressure and grip force.

Approach 6: Examine the Responses/Health Effects

(a) Psychophysical responses using human subjects

(b) Physiological and pathological effects using animal models





Approach 7: Examine the Hand-Arm Vibration Syndrome by Developing New Methods or Improving the Existing Test Methods

An improved thermal perception test method

Vibrotactile perception test

Outputs:
Publications
(Accomplished by 5-12 staff in the last 6 years)

- **> 50 journal articles**
- **> 60 conference presentations**
- **Three Awards:**

  2005: NIOSH Hamilton Award
  2006: Liberty Mutual Award
  2007: NIOSH Hamilton Award (honorable mention)

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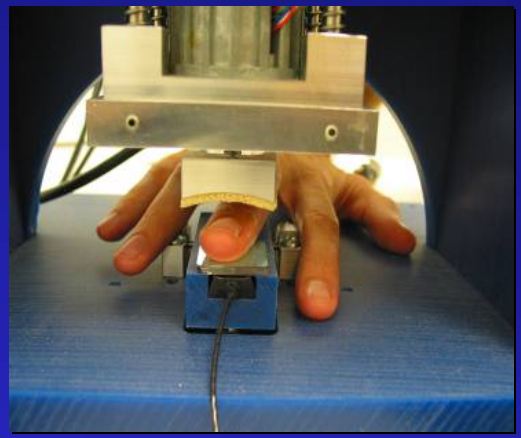
Technical Transfer Activities

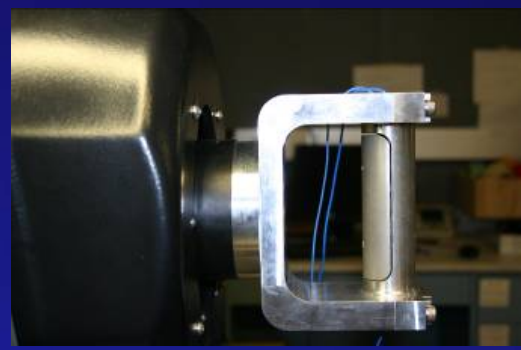
- Initiated a new series of conference (ACHV: American Conference on Human vibration) and organized the first one.
- Had more than 5 invited technical seminars.
- Provided NIOSH's Health Hazard Evaluation (HHE) for Cincinnati City Water, Sewer and Public Service Co.
- Provided consultations to public stakeholders (e.g., OSHA, US Navy, DOD, medical doctors, university graduate students, and many workers) - We frequently receive and response the public phone calls and emails related to vibration exposures.
- Is providing DOD with technical assistance to develop a general guideline for selections and purchases of tools and anti-vibration devices.

Intermediate Outcomes
Major New Technology and Method Developments

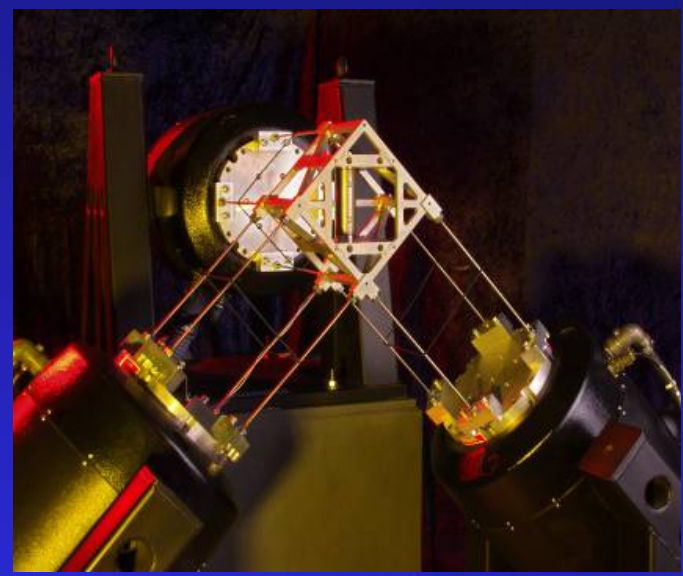
- Automated finger press test (patent pending)



- Instrumented handles and biodynamic response measurement method – it has been accepted by many researchers all over the world



- New tool and glove test methods
- A new method to characterize the grip force applied on cylindrical handles
- A novel 3-D hand-arm vibration test system (as a result of a joint effort with MB Dynamics, USA, and Spectral Dynamics, USA) – it has become a commercial product



Intermediate Outcomes
Standard Developments

- Coordinated US review; made a major contribution to the development of ISO 15230. (three NIOSH studies are cited)
- Provided test data for the on-going revision of ISO 8662-7.
- Provided inputs to the development of ANSI 2.70 (two NIOSH studies are cited)
- Provided new frequency weightings for future revisions of ISO 5349.
- Provided data for future revisions of ISO 8662-2.
- Provided useful results and recommendations for improving ISO 10819 (four NIOSH studies are cited in the preliminary revision)
- Taking a leading role in the revision of ISO 10068.

Summary and Further Studies

Systematically examine the pathway, resolve scientific issues, and find practical solutions for vibration-induced injuries and disorders